No.	Publication No.	Title
1.	06 - 112289(1994)	C-V CHARACTERISTIC CONVERSION METHOD IN CONTACTLESS C-V MEASURING DEVICE

PATENT ABSTRACTS OF JAPAN

(11)Publication number : 06-112289
(43)Date of publication of application : 22.04.1994

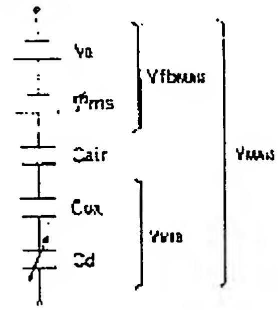
(51)Int.Cl. H01L 21/66

(21)Application number : 04-280831
(22)Date of filing : 25.09.1992

(71)Applicant : DAINIPPON SCREEN MFG CO LTD
(72)Inventor : KONO MOTOHIRO
KUSUDA TATSUFUMI
NAKATANI IKUHIRO

(54) C-V CHARACTERISTIC CONVERSION METHOD IN CONTACTLESS C-V MEASURING DEVICE

(57)Abstract:
PURPOSE: To obtain an equal characteristic with a C-V characteristic of the MIS structure by converting the C-V characteristic of the MAIS structure obtained by a contactless C-V measurement device.
CONSTITUTION: Voltage VQ caused by charge inside an insulating film, a difference in a work function ϕms between a aubstrate material of the semiconductor wafer and a material of an electrode for measurement, a capacity of a gap Cair, the capacity Cox of the insulating film and an equivalent circuit including the capacity Cd of a depletion layer of the semiconductor wafer are assumed, and according to this equivalent circuit, a C-V characteristic of the MAIS is converted to a C-V characteristic of the MIS structure.



$$V_{MIS} = (V_{MAIS} - V_{fbMAIS}) \times C_{MAIS}/C_{MIS} + V_{fbMIS}$$

$$V_{fbMAIS} = \phi ms - \frac{Qb}{Co} = \phi ms + V_Q$$

$$V_{fbMIS} = \phi ms - \frac{Qb}{Cox} = \phi ms - V_Q \times Co/Cox$$

$$\frac{1}{C_{MIS}} = \frac{1}{Cd} + \frac{1}{Cox}$$

$$\frac{1}{C_{MAIS}} = \frac{1}{C_{MIS}} + \frac{1}{Cair}$$

$$\frac{1}{Co} = \frac{1}{Cair} + \frac{1}{Cox}$$

LEGAL STATUS

[Date of request for examination]	07.12.1995
[Date of sending the examiner's decision of rejection]	
[Kind of final disposal of application other than the examiner's decision of rejection or application converted registration]	
[Date of final disposal for application]	
[Patent number]	2709351
[Date of registration]	24.10.1997
[Number of appeal against examiner's decision of rejection]	
[Date of requesting appeal against examiner's decision of rejection]	
[Date of extinction of right]	24.10.2002

CLAIMS

[Claim(s)]
[Claim 1] How to change a C-V property acquired about said semiconductor wafer using a non-contact C-V measuring device equipped with an electrode for measurement held by separating a gap to a semiconductor wafer which is characterized by providing the following, and which has an insulator layer A production process which acquires the 1st C-V property with said non-contact C-V measuring device Voltage resulting from a charge in an insulator layer of said semiconductor wafer A difference of a work function between substrate material of said semiconductor wafer, and material of said electrode for measurement A production process which searches for the 2nd C-V property in the imagination condition that said gap cannot be found and said electrode for measurement touched said semiconductor wafer, supposing an equal circuit containing capacity of said gap, capacity of said insulator layer, and capacity of a depletion layer of said semiconductor wafer by changing said 1st C-V property according to this equal circuit

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Industrial Application] This invention relates to the method of searching for a property equivalent to the C-V property especially acquired with a contact mold C-V measuring device, about the method of changing the C-V property acquired with the non-contact C-V measuring device.

[0002]

[Description of the Prior Art] C-V measurement is used as one of the methods which evaluates the surface state of a semiconductor wafer. In the conventional C-V measurement, although the electrode for measurement was formed on the surface of a semiconductor wafer, in the process which forms the electrode, movable ion may have mixed into the insulator layer of a semiconductor wafer. Therefore, when it was estimated as a result of C-V measurement that there are many amounts of movable ion in an insulator layer, by the conventional method, it was not able to distinguish whether a cause is in the process of insulator layer formation, and whether a cause would be in the process of electrode formation.

[0003] Then, these people develop the equipment which performs C-V measurement by non-contact, without forming an electrode on an insulator layer, and are indicating the equipment to JP,4-132236,A. Drawing 5 is the conceptual diagram of this non-contact C-V measuring device. With this equipment, the electrode 201 for measurement is held through about 1 micrometer or less gap **G from the surface of the semiconductor wafer 100, and a C-V property is measured by impressing alternating voltage between this electrode 201 for measurement, and the semiconductor wafer 100. In addition, below, the structure of the above electrode / air space / insulator layer / semiconductor substrates is called MAIS (Metal/Air/Insulator/Semiconductor) structure. This is the same with calling structure without an air space (gap) metal-insulator-semiconductor structure (Metal/Insulator/Semiconductor).

[0004]

[Problem(s) to be Solved by the Invention] Drawing 6 (A) is a graph which shows an example of the C-V property of the MAIS structure acquired with a non-contact C-V measuring device, and drawing 6 (B) is a graph which shows an example of the C-V property of the metal-insulator-semiconductor structure acquired with a contact mold C-V measuring device. The C-V property of MAIS structure differs in the configuration of the C-V curve from the C-V property of metal-insulator-semiconductor structure considerably so that these graphs may show. Moreover, the value of the flat band voltage Vfb obtained from C-V curve also has a remarkable difference.

[0005] Since it was performed based on the C-V property of metal-insulator-semiconductor structure from the former, also when a non-contact C-V measuring device is used, as for the process of a semiconductor wafer, it is desirable that a property equivalent to the C-V property of metal-insulator-semiconductor structure is acquired.

[0006] This invention is made in order to solve the above-mentioned technical problem in the conventional technology, and it aims at acquiring a property equivalent to the C-V property of metal-insulator-semiconductor structure by changing the C-V property of the MAIS structure acquired with the non-contact C-V measuring device.

[0007]

[Means for Solving the Problem] In order to solve an above-mentioned technical problem, a method by this invention A non-contact C-V measuring device equipped with an electrode for measurement held by separating a gap to a semiconductor wafer which has an insulator layer is used. A production process which is the method of changing a C-V property acquired about said semiconductor wafer, and acquires the 1st C-V property with said non-contact C-V measuring device, A difference of a work function between voltage resulting from a charge in an insulator layer of said semiconductor wafer, and substrate material of said semiconductor wafer and material of said electrode for measurement, Supposing an equal circuit containing capacity of said gap, capacity of said insulator layer, and capacity of a depletion layer of said semiconductor wafer by changing said 1st C-V property according to this equal circuit It has a production process which searches for the 2nd C-V property in the imagination condition that said gap cannot be found and said electrode for measurement touched said semiconductor wafer. In addition, a "C-V property" in this invention is the term which it not only points out the C-V curve itself, but can be interpreted as a characteristic value acquired from C-V curve like flat band voltage.

[0008]

[Function] Since an equal circuit including the voltage resulting from the charge in an insulator layer, and an electrode and the work function difference of a semiconductor substrate is assumed, the 2nd C-V property equivalent to the C-V property of metal-insulator-semiconductor structure can be searched for.

[0009]

[Example] A. View drawing 1 of conversion of a C-V property is explanatory drawing showing the equal circuit about the capacity of MAIS structure. Bias voltage VMIS concerning the depletion layer and oxide film of a semiconductor substrate The relation with bias voltage VMAIS concerning the whole MAIS structure is expressed as follows according to voltage distributive law.

VMIS =VMAISxCMAIS/CMIS -- (1)

Here, CMAIS is a synthetic capacity of MAIS structure, CMIS is a synthetic capacity of metal-insulator-semiconductor structure, and it is expressed with a degree type, respectively.

1/CMIS =1/Cd+1/Cox -- (2)

1-/CMAIS=1-/CMIS+1-/Cair -- (3)

Cd The capacity of the depletion layer formed in the semiconductor substrate 100 and Cox are the capacity of an oxide film 102, and Cair. It is the capacity of a gap.

[0010] C-V curve obtained with a non-contact C-V measuring device is a curve which shows bias voltage VMAIS of MAIS structure, and the relation with the synthetic capacity CMAIS. By the way, synthetic capacity CMIS of the right-hand side of the above-mentioned (1) formula It asks using (3) types. Namely, capacity Cair of a gap It can compute by measuring the magnitude of gap **G with a non-contact C-V measuring device, and is the capacity Cair of this gap. (3) types are followed from the synthetic capacity CMAIS of MAIS structure, and it is the synthetic capacity CMIS of metal-insulator-semiconductor structure. It is computable.

[0011] Thus, synthetic capacity CMIS of the acquired metal-insulator-semiconductor structure If it uses, according to (1) type, bias voltage VMAIS of MAIS structure is convertible for bias voltage VMIS of metal-insulator-semiconductor structure. This bias voltage VMIS Synthetic capacity CMIS Relation is C-V curve of metal-insulator-semiconductor structure.

[0012] However, when the C-V property of metal-insulator-semiconductor structure was searched for according to (1) type, it became clear that the following problems occurred. Namely, voltage VQ which originates in the voltage actually impressed to MAIS structure or metal-insulator-semiconductor structure at the charge in an oxide film Difference phims of the work function between electrode material and semiconductor substrate material is contained. However, since these voltage amount contributed VQ and phims are disregarded in the equal circuit of drawing 1, both the C-V properties changed and acquired by (1) type give a right result, only when these voltage amount contributed VQ and phims are 0.

[0013] Voltage VQ by the charge in an oxide film When difference phims of a work function is taken into consideration, the equal circuit of MAIS structure is shown in drawing 2. In the equal circuit of drawing 2, a degree type is materialized instead of (1) type.

VMIS =(VMAIS-VfbMAIS) xCMAIS/CMIS -- (4)

VfbMAIS=phi ms-Qfb/CO =phims+VQ -- (5)

1/CO =1/Cair+1/Cox -- (6)

Here, the flat band voltage with which VfbMAIS is obtained from C-V curve of MAIS structure, and Qfb are the amount of charges in an oxide film, and CO. It is a synthetic capacity of an oxide film and a gap.

[0014] However, bias voltage VMIS given by (4) formulas Flat band voltage is the thing of the ideal condition of zero (namely, phims=0, Qfb=0). Bias voltage VMIS* of metal-insulator-semiconductor structure is flat-band-voltage VfbMIS of metal-insulator-semiconductor structure to the right-hand side of (4) types. It is given by the added degree type.

VMIS*=(VMAIS-VfbMAIS) xCMAIS/CMIS+VfbMIS -- (7)

Here, it is flat-band-voltage VfbMIS of metal-insulator-semiconductor structure. It is shown by the degree type.

VfbMIS =phi ms-Qfb/Cox=phi ms+VQ xCO / Cox -- (8)

[0015] Flat-band-voltage VfbMIS of metal-insulator-semiconductor structure It is computed in the following procedures. First, deformation of the above-mentioned (5) formula and (6) types gives the amount Qfb of charges in an oxide film by the degree type.

Qfb=(phims-VfbMAIS)/(1/Cair+1/Cox) -- (9)

And flat-band-voltage VfbMIS [in / by substituting for the above-mentioned (8) formula the amount Qfb of charges in an oxide film computed by (9) formulas / metal-insulator-semiconductor structure] It is computed. In addition, the capacity Cox of an oxide film 102 is computed from the specific inductive capacity of an oxide film, and the thickness of an oxide film in this case.

[0016] As mentioned above, C-V curve obtained with a non-contact C-V measuring device is a curve which shows bias voltage VMAIS and the relation with the synthetic capacity CMAIS of MAIS structure. Then, bias voltage VMIS* converted into metal-insulator-semiconductor structure is computed according to the above-mentioned (7) formula, and it is the synthetic capacity CMIS. C-V curve in metal-insulator-semiconductor structure can be obtained by computing according to the above-mentioned (3) formula. Moreover, flat-band-voltage VfbMIS of metal-insulator-semiconductor structure According to the above-mentioned (8) formula and (9) types, it is computable.

[0017] B. The configuration and example drawing 3 of measurement of equipment are a conceptual diagram showing the configuration of the non-contact C-V measuring device which measures a C-V property, measuring the gap between the electrode for measurement, and the surface of a semiconductor wafer. This non-contact C-V measuring device is equipped with standing ways 1, the electrostrictive actuator 2 installed in the lower part of standing ways 1, and the stand 3 installed in the lower part by the pan of an electrostrictive actuator 2. Prism 4 is installed in the base of a stand 3. Moreover, the laser oscillation machines 5, such as GaAlAs laser, are fixed to one slant face of a stand 3, and the photo sensors 6, such as a photodiode, are being fixed to the slant face of another side.

[0018] Base 4a of prism 4 is installed in parallel with the surface (parallel xy plane) of the sample base 7 in which the semiconductor wafer 100 is laid. The ring-like electrode 201 for measurement is formed in base 4a of prism 4. The semiconductor wafer 100 is held on the sample base 7 through the gap G, and it is set to the lower part of prism 4 so that surface 100a of the semiconductor wafer 100 may become almost parallel to base 4a of prism 4. They are gaps G and dair by using the tunnel effect of the laser beam by which total reflection is carried out by base 4a of prism 4 in this non-contact C-V measuring device, as explained by JP,4-132236,A in full detail. The value is measured.

[0019] The positional controller 11 is connected to the electrostrictive actuator 2, and a stand 3 is moved in the direction of z according to the voltage given from a positional controller 11. The actinometry machine 12 is connected to a photo sensor 6, and the impedance meter 13 is connected to the electrode 201 for measurement, and the metal sample base 7, respectively. An impedance meter 13 is a device which measures a synthetic capacity between the electrode 201 for measurement, and the sample base 7. The positional controller 11, the actinometry machine 12, and the impedance meter 13 are connected to the host controller 14, and control of the whole measuring device and obtained processing of data are performed by this host controller 14. In addition, as a host controller 14, a personal computer is used, for example.

[0020] Drawing 4 (A) is a graph which shows the C-V property of the MAIS structure measured using the non-contact C-V measuring device. Moreover, drawing 4 (B) is a graph which shows the C-V property of the metal-insulator-semiconductor structure acquired by changing the C-V property of drawing 4 (A) according to the above-mentioned conversion method. In drawing 4 (A), it is [the thickness dox of an oxide film and] a gap dair as experiment conditions. Dopant concentration Nd of a semiconductor substrate (silicon) It is indicated.

[0021] Flat-band-voltage VfbMAIS obtained from C-V curve of the MAIS structure of drawing 4 (A) is -0.338 volt. Flat-band-voltage VfbMIS obtained from C-V curve of drawing 4 (B) on the other hand It is 0.206 volts and the result equivalent to a contact mold C-V measuring device is obtained. Moreover, the thing equivalent to a contact mold C-V measuring device also about the whole C-V curve of drawing 4 (B) is obtained.

[0022] In addition, this invention can be applied not only when changing the C-V property measured with the non-contact C-V measuring device of drawing 3 but when changing the C-V property acquired using the non-contact C-V measuring device generally equipped with the electrode for measurement held by separating a gap to a semiconductor wafer. Moreover, this invention can be carried out in various modes in

the range which is not restricted to the above-mentioned example and does not deviate from that summary.

[0023]

[Effect of the Invention] Since an equal circuit including the voltage resulting from the charge in an insulator layer, and an electrode and the work function difference of a semiconductor substrate is assumed according to the C-V property conversion method of this invention as explained above, it is effective in the ability to search for a property equivalent to the C-V property of metal-insulator-semiconductor structure based on the C-V property of MAIS structure.

[Translation done.]

TECHNICAL FIELD

[Industrial Application] This invention relates to the method of searching for a property equivalent to the C-V property especially acquired with a contact mold C-V measuring device, about the method of changing the C-V property acquired with the non-contact C-V measuring device.

[Translation done.]

PRIOR ART

[Description of the Prior Art] C-V measurement is used as one of the methods which evaluates the surface state of a semiconductor wafer. In the conventional C-V measurement, although the electrode for measurement was formed on the surface of a semiconductor wafer, in the process which forms the electrode, movable ion may have mixed into the insulator layer of a semiconductor wafer. Therefore, when it was estimated as a result of C-V measurement that there are many amounts of movable ion in an insulator layer, by the conventional method, it was not able to distinguish whether a cause is in the process of insulator layer formation, and whether a cause would be in the process of electrode formation.
[0003] Then, these people develop the equipment which performs C-V measurement by non-contact, without forming an electrode on an insulator layer, and are indicating the equipment to JP,4-132236,A. Drawing 5 is the conceptual diagram of this non-contact C-V measuring device. With this equipment, the electrode 201 for measurement is held through about 1 micrometer or less gap **G from the surface of the semiconductor wafer 100, and a C-V property is measured by impressing alternating voltage between this electrode 201 for measurement, and the semiconductor wafer 100. In addition, below, the structure of the above electrode / air space / insulator layer / semiconductor substrates is called MAIS (Metal/Air/Insulator/Semiconductor) structure. This is the same with calling structure without an air space (gap) metal-insulator-semiconductor structure (Metal/Insulator/Semiconductor).

[Translation done.]

EFFECT OF THE INVENTION

[Effect of the Invention] Since an equal circuit including the voltage resulting from the charge in an insulator layer, and an electrode and the work function difference of a semiconductor substrate is assumed according to the C-V property conversion method of this invention as explained above, it is effective in the ability to search for a property equivalent to the C-V property of metal-insulator-semiconductor structure based on the C-V property of MAIS structure.

[Translation done.]

TECHNICAL PROBLEM

[Problem(s) to be Solved by the Invention] Drawing 6 (A) is a graph which shows an example of the C-V property of the MAIS structure acquired with a non-contact C-V measuring device, and drawing 6 (B) is a graph which shows an example of the C-V property of the metal-insulator-semiconductor structure acquired with a contact mold C-V measuring device. The C-V property of MAIS structure differs in the configuration of the C-V curve from the C-V property of metal-insulator-semiconductor structure considerably so that these graphs may show. Moreover, the value of the flat band voltage Vfb obtained from C-V curve also has a remarkable difference.
[0005] Since it was performed based on the C-V property of metal-insulator-semiconductor structure from the former, also when a non-contact C-V measuring device is used, as for the process of a semiconductor wafer, it is desirable that a property equivalent to the C-V property of metal-insulator-semiconductor structure is acquired.
[0006] This invention is made in order to solve the above-mentioned technical problem in the conventional technology, and it aims at acquiring a property equivalent to the C-V property of metal-insulator-semiconductor structure by changing the C-V property of the MAIS structure acquired with the non-contact C-V measuring device.

[Translation done.]

MEANS

[Means for Solving the Problem] In order to solve an above-mentioned technical problem, a method by this invention A non-contact C-V measuring device equipped with an electrode for measurement held by separating a gap to a semiconductor wafer which has an insulator layer is used. A production process which is the method of changing a C-V property acquired about said semiconductor wafer, and acquires the 1st C-V property with said non-contact C-V measuring device, A difference of a work function between voltage resulting from a charge in an insulator layer of said semiconductor wafer, and substrate material of said semiconductor wafer and material of said electrode for measurement, Supposing an equal circuit containing capacity of said gap, capacity of said insulator layer, and capacity of a depletion layer of said semiconductor wafer by changing said 1st C-V property according to this equal circuit It has a production process which searches for the 2nd C-V property in the imagination condition that said gap cannot be found and said electrode for measurement touched said semiconductor wafer. In addition, a "C-V property" in this invention is the term which it not only points out the C-V curve itself, but can be interpreted as a characteristic value acquired from C-V curve like flat band voltage.

[Translation done.]

OPERATION

[Function] Since an equal circuit including the voltage resulting from the charge in an insulator layer, and an electrode and the work function difference of a semiconductor substrate is assumed, the 2nd C-V property equivalent to the C-V property of metal-insulator-semiconductor structure can be searched for.

[Translation done.]

EXAMPLE

[Example] A. View drawing 1 of conversion of a C-V property is explanatory drawing showing the equal circuit about the capacity of MAIS structure. Bias voltage VMIS concerning the depletion layer and oxide film of a semiconductor substrate The relation with bias voltage VMAIS concerning the whole MAIS structure is expressed as follows according to voltage distributive law.
VMIS =VMAISxCMAIS/CMIS -- (1)
Here, CMAIS is a synthetic capacity of MAIS structure, CMIS is a synthetic capacity of metal-insulator-semiconductor structure, and it is expressed with a degree type, respectively.
1/CMIS =1/Cd+1/Cox -- (2)
1-/CMAIS=1-/CMIS+1-/Cair -- (3)
Cd The capacity of the depletion layer formed in the semiconductor substrate 100 and Cox are the capacity of an oxide film 102, and Cair. It is the capacity of a gap.
[0010] C-V curve obtained with a non-contact C-V measuring device is a curve which shows bias voltage VMAIS of MAIS structure, and relation with the synthetic capacity CMAIS. By the way, synthetic capacity CMIS of the right-hand side of the above-mentioned (1) formula It asks using (3) types. Namely, capacity Cair of a gap It can compute by measuring the magnitude of gap **G with a non-contact C-V measuring device, and is the capacity Cair of this gap. (3) types are followed from the synthetic capacity CMAIS of MAIS structure, and it is the synthetic capacity CMIS of metal-insulator-semiconductor structure. It is computable.
[0011] Thus, synthetic capacity CMIS of the acquired metal-insulator-semiconductor structure If it uses, according to (1) type, bias voltage VMAIS of MAIS structure is convertible for bias voltage VMIS of metal-insulator-semiconductor structure. This bias voltage VMIS Synthetic capacity CMIS Relation is C-V curve of metal-insulator-semiconductor structure.
[0012] However, when the C-V property of metal-insulator-semiconductor structure was searched for according to (1) type, it became clear that the following problems occurred. Namely, voltage VQ which originates in the voltage actually impressed to MAIS structure or metal-insulator-semiconductor structure at the charge in an oxide film Difference phims of the work function between electrode material and semiconductor substrate material is contained. However, since these voltage amount contributed VQ and phims are disregarded in the equal circuit of drawing 1 , both the C-V properties changed and acquired by (1) type give a right result, only when these voltage amount contributed VQ and phims are 0.
[0013] Voltage VQ by the charge in an oxide film When difference phims of a work function is taken into consideration, the equal circuit of MAIS structure is shown in drawing 2 . In the equal circuit of drawing 2 , a degree type is materialized instead of (1) type.
VMIS =(VMAIS-VfbMAIS) xCMAIS/CMIS -- (4)
VfbMAIS=phi ms-Qfb/CO =phims+VQ -- (5)
1/CO =1/Cair+1/Cox -- (6)
Here, the flat band voltage with which VfbMAIS is obtained from C-V curve of MAIS structure, and Qfb are the amount of charges in an oxide film, and CO. It is a synthetic capacity of an oxide film and a gap.
[0014] However, bias voltage VMIS given by (4) formulas Flat band voltage is the thing of the ideal condition of zero (namely, phims=0, Qfb=0). Bias voltage VMIS* of metal-insulator-semiconductor structure is flat-band-voltage VfbMIS of metal-insulator-semiconductor structure to the right-hand side of (4) types. It is given by the added degree type.
VMIS*=(VMAIS-VfbMAIS) xCMAIS/CMIS+VfbMIS -- (7)
Here, it is flat-band-voltage VfbMIS of metal-insulator-semiconductor structure. It is shown by the degree type.
VfbMIS =phi ms-Qfb/Cox=phi ms+VQ xCO / Cox -- (8)
[0015] Flat-band-voltage VfbMIS of metal-insulator-semiconductor structure It is computed in the following procedures. First, deformation of the above-mentioned (5) formula and (6) types gives the amount Qfb of charges in an oxide film by the degree type.
Qfb=(phims-VfbMAIS)/(1/Cair+1/Cox) -- (9)
And flat-band-voltage VfbMIS [in / by substituting for the above-mentioned (8) formula the amount Qfb of charges in an oxide film computed by (9) formulas / metal-insulator-semiconductor structure] It is computed. In addition, the capacity Cox of an oxide film 102 is computed from the specific inductive capacity of an oxide film, and the thickness of an oxide film in this case.
[0016] As mentioned above, C-V curve obtained with a non-contact C-V measuring device is a curve which shows bias voltage VMAIS and the relation with the synthetic capacity CMAIS of MAIS structure. Then, bias voltage VMIS* converted into metal-insulator-semiconductor structure is computed according to the above-mentioned (7) formula, and it is the synthetic capacity CMIS. C-V curve in metal-insulator-semiconductor structure can be obtained by computing according to the above-mentioned (3) formula. Moreover, flat-band-voltage VfbMIS of metal-insulator-semiconductor structure According to the above-mentioned (8) formula and (9) types, it is computable.
[0017] B. The configuration and example drawing 3 of measurement of equipment are a conceptual diagram showing the configuration of the non-contact C-V measuring device which measures a C-V property, measuring the gap between the electrode for measurement, and the surface of a semiconductor wafer. This non-contact C-V measuring device is equipped with standing ways 1, the electrostrictive actuator 2 installed in the lower part of standing ways 1, and the stand 3 installed in the lower part by the pan of an electrostrictive actuator 2. Prism 4 is installed in the base of a stand 3. Moreover, the laser oscillation machines 5, such as GaAlAs laser, are fixed to one slant face of a stand 3, and the photo sensors 6, such as a photodiode, are being fixed to the slant face of another side.

[0018] Base 4a of prism 4 is installed in parallel with the surface (parallel xy plane) of the sample base 7 in which the semiconductor wafer 100 is laid. The ring-like electrode 201 for measurement is formed in base 4a of prism 4. The semiconductor wafer 100 is held on the sample base 7 through the gap G, and it is set to the lower part of prism 4 so that surface 100a of the semiconductor wafer 100 may become almost parallel to base 4a of prism 4. They are gaps G and dair by using the tunnel effect of the laser beam by which total reflection is carried out by base 4a of prism 4 in this non-contact C-V measuring device, as explained by JP,4-132236,A in full detail. The value is measured.
[0019] The positional controller 11 is connected to the electrostrictive actuator 2, and a stand 3 is moved in the direction of z according to the voltage given from a positional controller 11. The actinometry machine 12 is connected to a photo sensor 6, and the impedance meter 13 is connected to the electrode 201 for measurement, and the metal sample base 7, respectively. An impedance meter 13 is a device which measures a synthetic capacity between the electrode 201 for measurement, and the sample base 7. The positional controller 11, the actinometry machine 12, and the impedance meter 13 are connected to the host controller 14, and control of the whole measuring device and obtained processing of data are performed by this host controller 14. In addition, as a host controller 14, a personal computer is used, for example.
[0020] Drawing 4 (A) is a graph which shows the C-V property of the MAIS structure measured using the non-contact C-V measuring device. Moreover, drawing 4 (B) is a graph which shows the C-V property of the metal-insulator-semiconductor structure acquired by changing the C-V property of drawing 4 (A) according to the above-mentioned conversion method. In drawing 4 (A), it is [the thickness dox of an oxide film and] a gap dair as experiment conditions. Dopant concentration Nd of a semiconductor substrate (silicon) It is indicated.
[0021] Flat-band-voltage VfbMAIS obtained from C-V curve of the MAIS structure of drawing 4 (A) is -0.338 volt. Flat-band-voltage VfbMIS obtained from C-V curve of drawing 4 (B) on the other hand It is 0.206 volts and the result equivalent to a contact mold C-V measuring device is obtained. Moreover, the thing equivalent to a contact mold C-V measuring device also about the whole C-V curve of drawing 4 (B) is obtained.
[0022] In addition, this invention can be applied not only when changing the C-V property measured with the non-contact C-V measuring device of drawing 3 but when changing the C-V property acquired using the non-contact C-V measuring device generally equipped with the electrode for measurement held by separating a gap to a semiconductor wafer. Moreover, this invention can be carried out in various modes in the range which is not restricted to the above-mentioned example and does not deviate from that summary.

[Translation done.]

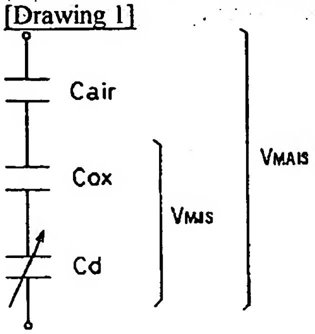
DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] Explanatory drawing showing the equal circuit about the capacity of MAIS structure.
[Drawing 2] Explanatory drawing showing the equal circuit of the MAIS structure for C-V property conversion.
[Drawing 3] The conceptual diagram showing the configuration of a non-contact C-V measuring device.
[Drawing 4] The graph which shows the measurement result of the C-V property of MAIS structure, and the C-V property of the metal-insulator-semiconductor structure which changed this and was acquired.
[Drawing 5] The conceptual diagram of a non-contact C-V measuring device.
[Drawing 6] The graph which compares and shows the C-V property of MAIS structure and metal-insulator-semiconductor structure.
[Description of Notations]
1 -- Standing ways
2 -- Electrostrictive actuator
3 -- Stand
4 -- Prism
5 -- Laser oscillation machine
6 -- Photo sensor
7 -- Sample base
11 -- Positional controller
12 -- Actinometry machine
13 -- Impedance meter
14 -- Host controller
100 -- Semiconductor wafer
101 -- Substrate
102 -- Insulator layer
201 -- Electrode for measurement
Cair -- Capacity of a gap
Cd -- Capacity of the depletion layer of a semiconductor wafer
Cox -- Capacity of an oxide film
Co -- Synthetic capacity of an oxide film and a gap
CMAIS -- Capacity of MAIS structure
CMIS -- Capacity of metal-insulator-semiconductor structure
Flat band voltage of VfbMAIS--MAIS structure
VfbMIS -- Flat band voltage of metal-insulator-semiconductor structure
VMAIS -- Bias voltage of MAIS structure
VMIS* -- Bias voltage of metal-insulator-semiconductor structure

[Translation done.]

DRAWINGS

[Drawing 1]

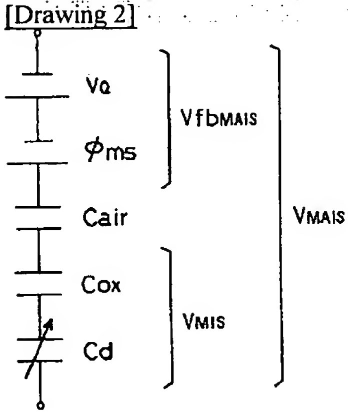


$$V_{MIS} = V_{MAIS} \times C_{MAIS} / C_{MIS}$$

$$\frac{1}{C_{MIS}} = \frac{1}{Cd} + \frac{1}{Cox}$$

$$\frac{1}{C_{MAIS}} = \frac{1}{C_{MIS}} + \frac{1}{Cair}$$

[Drawing 2]



$$V_{MIS}* = (V_{MAIS} - Vfb_{MAIS}) \times C_{MAIS} / C_{MIS} + Vfb_{MIS}$$

$$Vfb_{MAIS} = \phi ms - \frac{Qfb}{Co} = \phi ms + V_Q$$

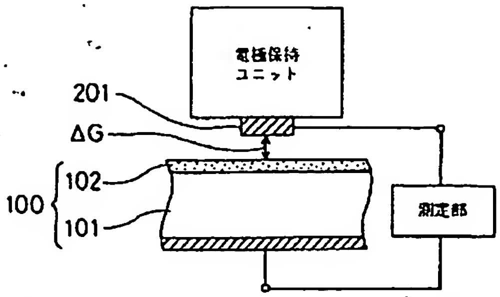
$$Vfb_{MIS} = \phi ms - \frac{Qfb}{Cox} = \phi ms + V_Q \times Co / Cox$$

$$\frac{1}{C_{MIS}} = \frac{1}{Cd} + \frac{1}{Cox}$$

$$\frac{1}{C_{MAIS}} = \frac{1}{C_{MIS}} + \frac{1}{Cair}$$

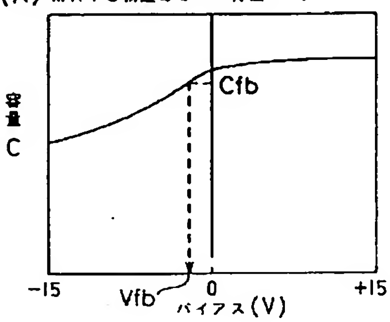
$$\frac{1}{Co} = \frac{1}{Cair} + \frac{1}{Cox}$$

[Drawing 5]

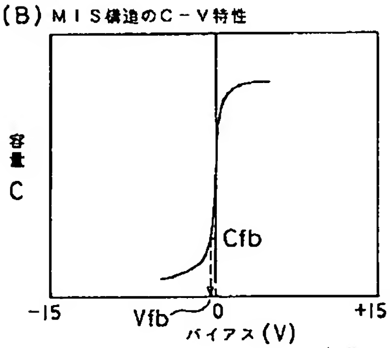


[Drawing 6]

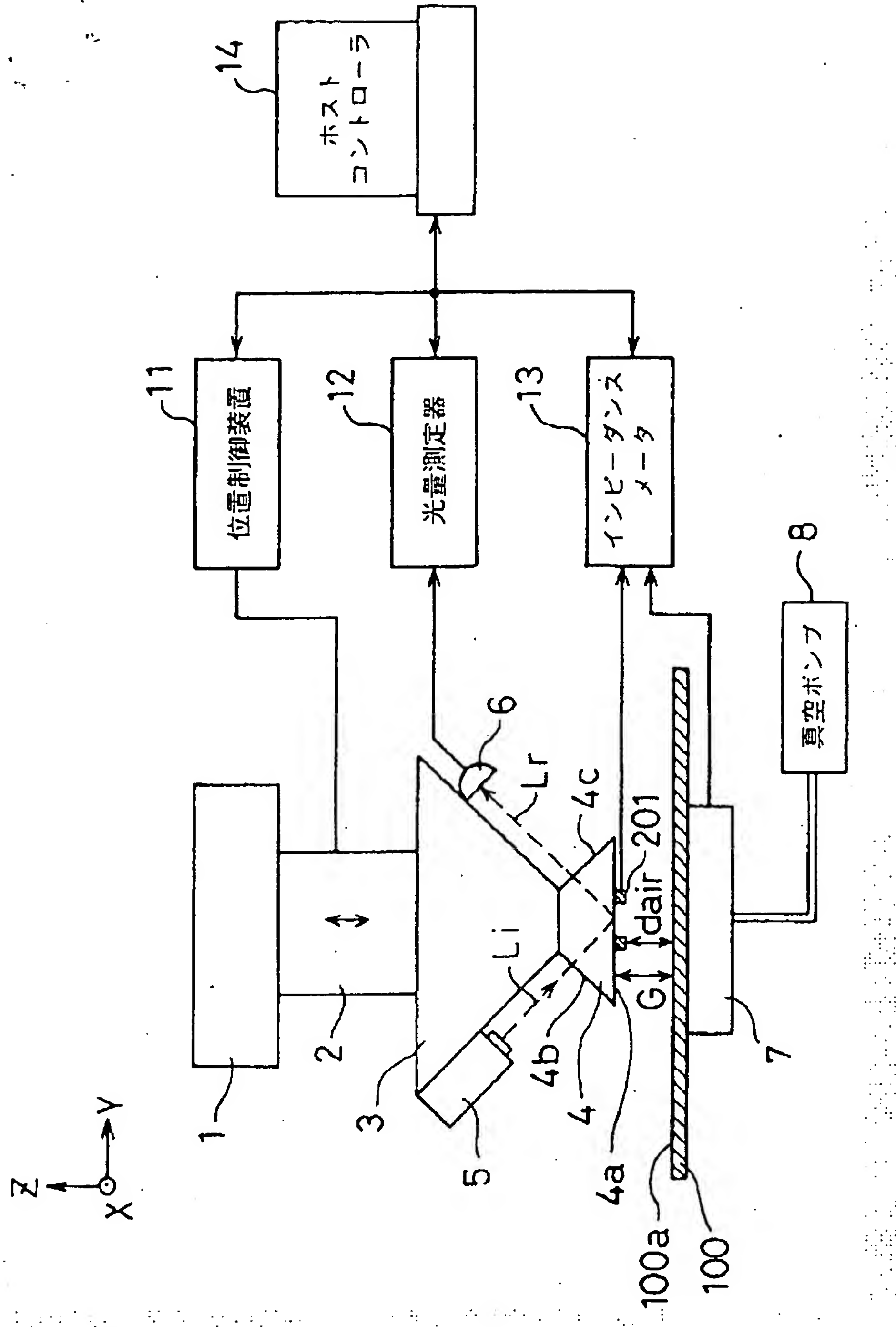
(A) MAIS構造のC－V特性



(B) MIS構造のC－V特性



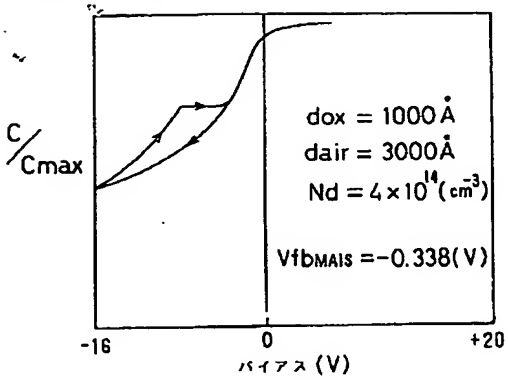
[Drawing 3]



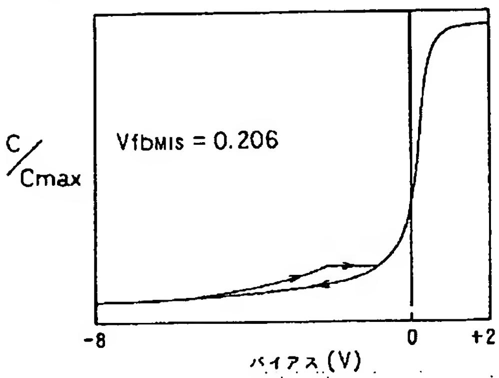
ホスト
コントローラ
14
位置制御装置
11
光量測定器
12
インピーダンス
メータ
13
真空ポンプ
8
Z
Y
X
1
2
3
4
4a
4b
4c
5
6
7
Li
Lr
G
dair
201
100a
100

[Drawing 4]

(A)



(B)



[Translation done.]